Amendments to the Claims

1. (currently amended) In a charged-particle-beam (CPB) microlithography system comprising, on an optical axis, a CPB optical system including an illumination-optical system and a projection-optical system, wherein the illumination-optical system illuminates a selected region on a reticle with a charged-particle illumination beam to form a patterned beam carrying an aerial image of the illuminated reticle region, and the projection-optical system causes the patterned beam to form an actual image of the illuminated reticle region on a corresponding region on a surface of a substrate, a device for detecting and canceling magnetic fields external to the CPB optical system, comprising:

a magnetic-field sensor situated and configured to detect a magnetic field external to the CPB optical system;

a magnetic-field-compensation coil situated between the illumination-optical system and the projection-optical system or between the projection-optical system and ~~a~~the substrate ~~stage~~; and

a magnetic-field-compensation circuit connected to the magnetic-field-compensation coil and configured to deliver an electrical current to the magnetic-field-compensation coil sufficient in direction and magnitude to cause the magnetic-field-compensation coil to produce a corresponding magnetic field that cancels at least a portion of the external magnetic field detected by the magnetic-field sensor.

2. (original) The device of claim 1, wherein:

the microlithography system comprises a reticle stage situated between the illumination-optical system and the projection-optical system;

the reticle is mounted on the reticle stage; and

the magnetic-field sensor and the magnetic-field-compensation coil are situated between the illumination-optical system and the reticle stage.

3. (original) The device of claim 1, wherein:

the magnetic-field sensor and magnetic-field-compensation coil each comprise a respective set of three coils, one coil for each of an x-axis direction, a y-axis direction, and a z-axis direction, respectively, of a Cartesian coordinate system of the CPB optical system, wherein the optical axis is parallel to the z-axis direction;

the coils of the magnetic-field sensor detect respective components of the external magnetic field in the x-axis, y-axis, and z-axis directions, respectively; and

the coils of the magnetic-field-compensation coil generate respective magnetic fields in the x-axis, y-axis, and z-axis directions, respectively.

4. (original) The device of claim 3, wherein the coils of the magnetic-field sensor comprise:

a z-axis coil wound about the z-axis and configured to detect a magnetic field in the z-axis direction;

an x-axis coil wound about an axis parallel to the x-axis and configured to detect a magnetic field in the x-axis direction; and

a y-axis coil wound about an axis parallel to the y-axis and configured to detect a magnetic field in the y-axis direction.

5. (original) The device of claim 4, wherein the coils of the magnetic-field-compensation coil comprise:

a z-axis coil wound about the z-axis and configured to generate a magnetic field oriented in the z-axis direction;

an x-axis coil wound about an axis parallel to the y-axis and configured to generate a magnetic field oriented in the x-axis direction; and

a y-axis coil wound about an axis parallel to the x-axis and configured to generate a magnetic field in the y-axis direction.

6. (original) The device of claim 1, wherein the magnetic-field sensor is displaced from the optical axis farther than the magnetic-field-compensation coil.

7. (original) The device of claim 1, wherein the magnetic-field sensor comprises a coil configured to serve as both a magnetic-field sensor coil and a magnetic-field-compensation coil.

8. (original) The device of claim 1, further comprising:

a first magnetic-field sensor and a first magnetic-field-compensation coil situated between the illumination-optical system and the projection-optical system;

a second magnetic-field sensor and a second magnetic-field-compensation coil situated between the projection-optical system and the substrate stage;

a first magnetic-field-compensation circuit connected to the first magnetic-field-compensation coil; and

a second magnetic-field-compensation circuit connected to the second magnetic-field-compensation coil.

9. (original) The device of claim 8, wherein:

each of the first and second magnetic-field sensors and each of the first and second magnetic-field-compensation coils comprises a respective set of three coils, one coil for each of an x-axis direction, a y-axis direction, and a z-axis direction, respectively, of a Cartesian coordinate system of the CPB optical system, wherein the optical axis is parallel to the z-axis direction;

the respective coils of each magnetic-field sensor detect respective components of the external magnetic field in the x-axis, y-axis, and z-axis directions, respectively; and

the respective coils of each magnetic-field-compensation coil generate respective magnetic fields in the x-axis, y-axis, and z-axis directions, respectively.

10. (original) The device of claim 9, wherein the coils of each magnetic-field sensor comprise:

a respective z-axis coil wound about the z-axis and configured to detect a magnetic field in the z-axis direction;

a respective x-axis coil wound about an axis parallel to the y-axis and configured to detect a magnetic field in the x-axis direction; and

a respective y-axis coil wound about an axis parallel to the x-axis and configured to detect a magnetic field in the y-axis direction.

11. (currently amended) In a charged-particle-beam (CPB) microlithography method in which an illumination beam is directed by a CPB illumination-optical system onto a selected region of a pattern-defining reticle to produce a patterned beam carrying an aerial image of the illuminated reticle region, and the patterned beam is caused by ~~the~~a CPB projection-optical system, situated downstream of the illumination-optical system, to form an actual image of the illuminated reticle region on a corresponding region on a surface of a substrate, a method for detecting and canceling magnetic fields external to the CPB optical system, the method comprising:

detecting a magnetic field external to the CPB illumination-optical and projection-optical systems;

placing a magnetic-field-compensation coil ~~relative to~~between the CPB illumination-optical system and CPB projection-optical system or between the CPB projection-optical system and the substrate; and

based on the detected external magnetic field, supplying electric current to the magnetic-field-compensation coil to produce a corresponding magnetic field that cancels at least a portion of the detected external magnetic field.

12. (original) The method of claim 11, further comprising the steps of:

determining a ratio of the detected external magnetic field and the electric current supplied to the magnetic-field-compensation coil in advance; and

determining the electric current supplied to the magnetic-field-compensation coil based on the detected external magnetic field and the ratio.

13. (currently amended) A charged-particle-beam (CPB) optical system, comprising ~~a device as recited in claim 1~~:

an illumination-optical system situated upstream of a reticle along an optical axis;

a projection-optical system situated along the optical axis, downstream of the reticle and upstream of a substrate; and

a device for detecting and canceling magnetic fields external to the CPB optical system, the device comprising (i) a magnetic-field sensor situated and configured to detect a magnetic field external to the illumination-optical system and projection-optical system, (ii) a magnetic-field-compensation coil situated between the illumination-optical system and the projection-optical system or between the projection-optical system and the substrate, and (iii) a magnetic-field-compensation circuit connected to the magnetic-field-compensation coil and configured to deliver an electrical current to the magnetic-field-compensation coil to produce a corresponding magnetic field that cancels at least a portion of the external magnetic field detected by the magnetic-field sensor.

14. (canceled).

15. (currently amended) A charged-particle-beam (CPB) microlithography process, ~~performed using the CPB microlithography apparatus of claim 14~~comprising:

using a CPB illumination-optical system situated along an optical axis, directing an illumination beam onto a selected region of a pattern-defining reticle to produce a patterned beam carrying an aerial image of the illuminated reticle region;

using a CPB projection-optical system situated along the optical axis, causing the patterned beam to form an actual image of the illuminated reticle region on a corresponding region on a surface of a substrate situated downstream of the projection-optical system;

detecting a magnetic field external to the illumination-optical system and projection-optical system;

in response to the detected external magnetic field, producing a corresponding magnetic field locally in the vicinity of the optical axis either between the illumination-optical system and the projection-optical system or between the projection-optical system and the substrate so as to cancel at least a portion of the detected external magnetic field.

16. (currently amended) A process for manufacturing a microelectronic device, comprising:

performing a CPB microlithography step in which an illumination beam is directed by an illumination-optical system, situated along an optical axis, onto a selected region of a pattern-defining reticle to produce a patterned beam carrying an aerial image of the illuminated reticle region, and the patterned beam is directed by a projection-optical system, situated on the optical axis downstream of the illumination-optical system, to form an actual image of the illuminated reticle region on a corresponding region on a surface of a substrate situated downstream of the projection-optical system;

detecting a magnetic field external to the illumination-optical system and projection-optical system; and

in response to the detected external magnetic field, producing a corresponding magnetic field locally in the vicinity of the optical axis either between the illumination-optical system and the projection-optical system or between the projection-optical system and the substrate so as to cancel at least a portion of the detected external magnetic field ~~a CPB microlithography process as recited in claim 1~~.